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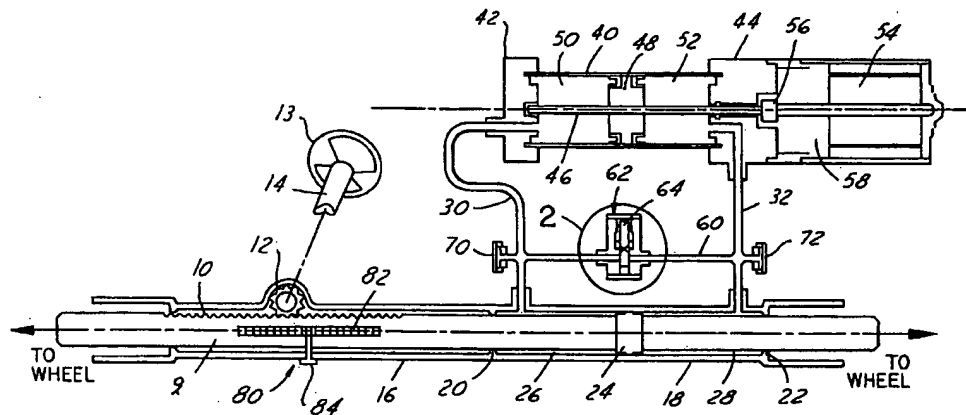
(12) **United States Patent**
Spadafora(10) **Patent No.:** **US 6,298,941 B1**
(45) **Date of Patent:** **Oct. 9, 2001**(54) **ELECTRO-HYDRAULIC POWER STEERING SYSTEM**(76) **Inventor:** **William Glenn Spadafora, 5055**
Sylvanview, Clarkston, MI (US) 48348(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.(21) **Appl. No.:** **09/492,623**(22) **Filed:** **Jan. 27, 2000****Related U.S. Application Data**(60) **Provisional application No. 60/117,890, filed on Jan. 29, 1999.**(51) **Int. Cl.⁷** **B62D 5/04; B62D 5/10; B62D 5/18**(52) **U.S. Cl.** **180/422; 180/417; 60/571; 701/41**(58) **Field of Search** **180/417, 421, 180/422, 428, 441, 442, 443, 444, 446; 701/41; 417/44.1, 45, 44.11, 18; 60/571, 572, 573, 494**(56) **References Cited****U.S. PATENT DOCUMENTS**

3,901,343	8/1975	Inoue .	
3,908,779	9/1975	Inoue .	
3,939,938	2/1976	Inoue .	
4,010,815	3/1977	Strauff .	
4,019,616	4/1977	Thorne .	
4,410,059	10/1983	Nakayama et al. .	
4,872,310 *	10/1989	Kaye	60/572
5,080,186	1/1992	Elser et al. .	
5,230,396	7/1993	Yasui .	
5,313,389	5/1994	Yasui .	

(List continued on next page.)

Primary Examiner—Anne Marie Boehler(74) **Attorney, Agent, or Firm—Reising, Ethington, Barnes, Kisselle, Learman & McCulloch, PC**(57) **ABSTRACT**

An electro-hydraulic power steering system comprising an elongated vehicle steering linkage rack with a rotatable steering gear in mesh with rack teeth and extending within an elongated power assist cylinder of a rack housing. A rack piston separates the power assist cylinder into first and second power assist working chambers filled with hydraulic fluid. An electric/hydrostatic steering assist module includes a hydraulic actuator cylinder with a linear drive screw extending lengthwise therein and journaled for bi-directional rotation and against axial displacement. An actuator piston is reciprocable but non-rotatable within the actuator cylinder and separates it into first and second hydraulic fluid filled actuating chambers. The drive screw is threadedly engaged with the actuator piston to produce bi-directional linear movement thereof as rotationally bi-directionally driven by a servo motor carried on the module. First and second fluid lines respectively communicate the first and second actuating chambers with the first and second power assist chambers such that the hydraulic fluid filling said actuating chambers is force fed to and from said first and second power assist chambers in response to motion of said actuator piston under control of the motor and drive screw. A fluid cross-over by-pass line connects the first and second fluid lines and contains a solenoid by-pass valve that when opened allows fluid to be merely displaced between the power assist chambers in by-pass relation to said actuator chambers. When the vehicle operator provides a steering input to the rack, the resultant motion of said rack and consequent motion of the rack piston creates a pressure differential in the rack power assist chambers which is sensed by two pressure sensors coupled one in each fluid line to thereby generate a corresponding pressure differential signal. An electronic controller utilizes the pressure differential signal to control the servo motor and thereby cause rotation of the drive screw to move the actuator piston in a proper direction to force sufficient hydraulic fluid from one of the actuator chambers into an associated one of the power assist chambers to thereby minimize the fluid pressure differential existing between said two pressure sensors and thus provide steering assist power in the power cylinder to assist the vehicle operator in manually applying torque via the steering wheel to achieve the desired motion of the rack to thereby move the steerable vehicle wheels.

23 Claims, 3 Drawing Sheets

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U.S. PATENT DOCUMENTS

5,373,911 12/1994 Yasui .
5,445,239 8/1995 Miller et al. .
5,558,177 9/1996 Inaguma et al. .

5,655,371 * 8/1997 Chuang et al. 60/571
5,704,250 1/1998 Black .
5,725,023 3/1998 Padula .

* cited by examiner